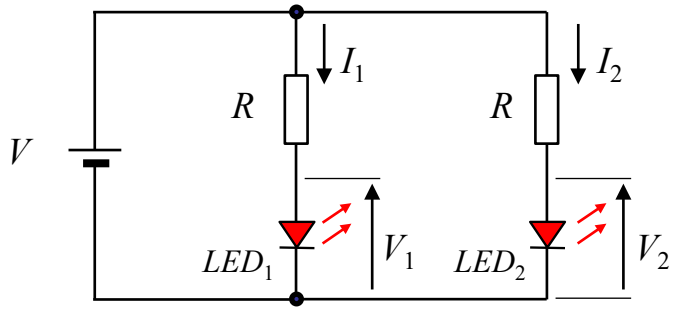
ディジタル回路講義資料

第5回 NAND, NOR, XOR回路

担当：古橋武



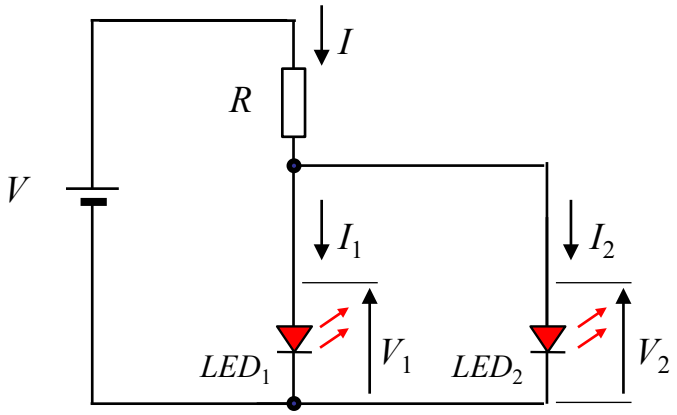
$$I_1 = \frac{V - V_1}{R}$$

$$I_2 = \frac{V - V_2}{R}$$

$V = 3[\mathrm{V}], V_1 = V_2 = 1.8[\mathrm{V}], R = 500[\Omega]$とすると

$$I_1 = I_2 = \frac{3 - 1.8}{500} = 2.4\,[\mathrm{mA}]$$

LED_1，LED_2 は明るく点く



$$I = \frac{V - V_s}{R} \quad (V_s \text{は} V_1, V_2 \text{のうち低い方})$$

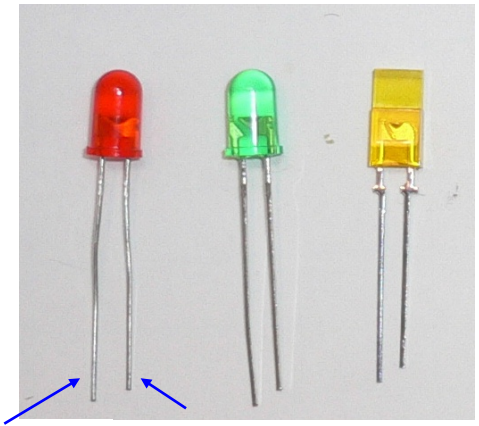
$$V = 3[\mathrm{V}], V_1 = V_2 = 1.8[\mathrm{V}], R = 500[\Omega] \text{とすると}$$

$$I = \frac{3 - 1.8}{500} = 2.4\,[\mathrm{mA}]$$

$$I_1 = I_2 = \frac{I}{2} = 1.2\,[\mathrm{mA}]$$

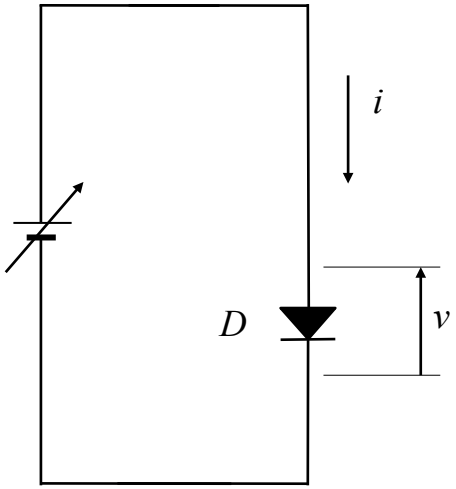
LED_1 , LED_2 は暗く点く.

LEDの特性

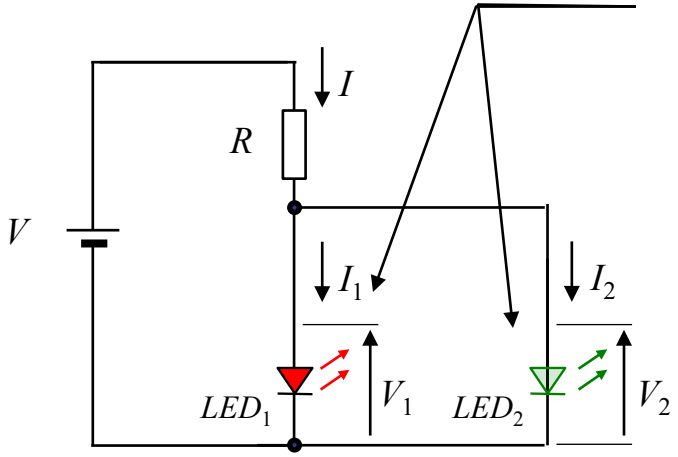


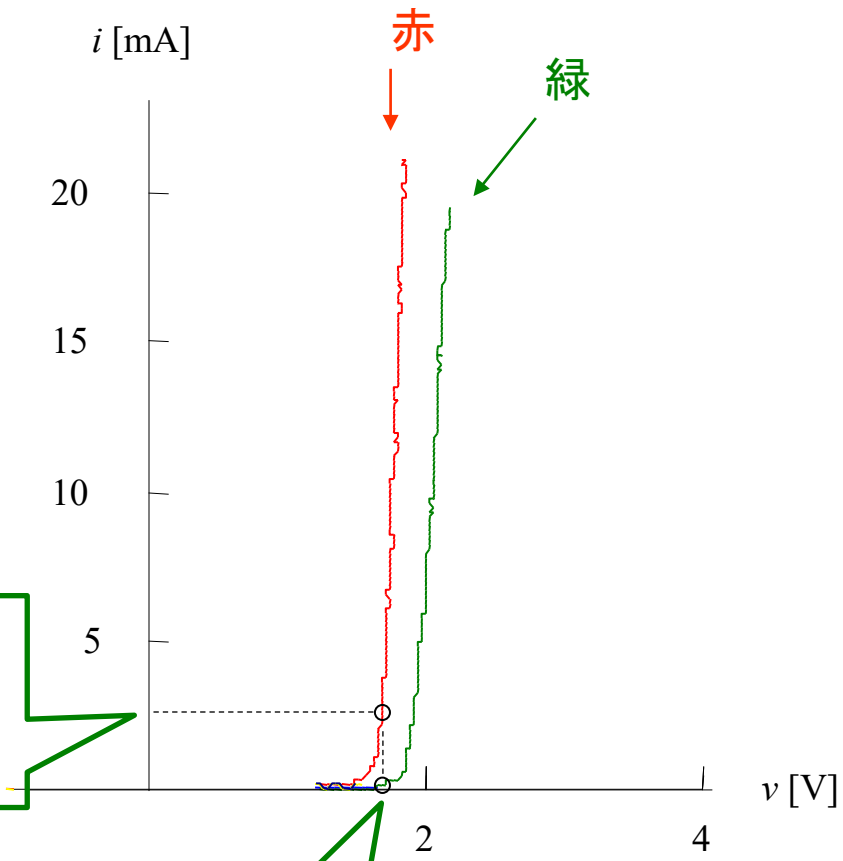
アノード
〔足の長い方〕

カソード



赤だけ点いて，緑は点かない．

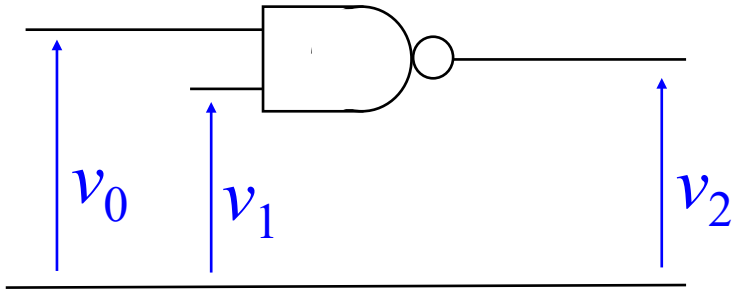


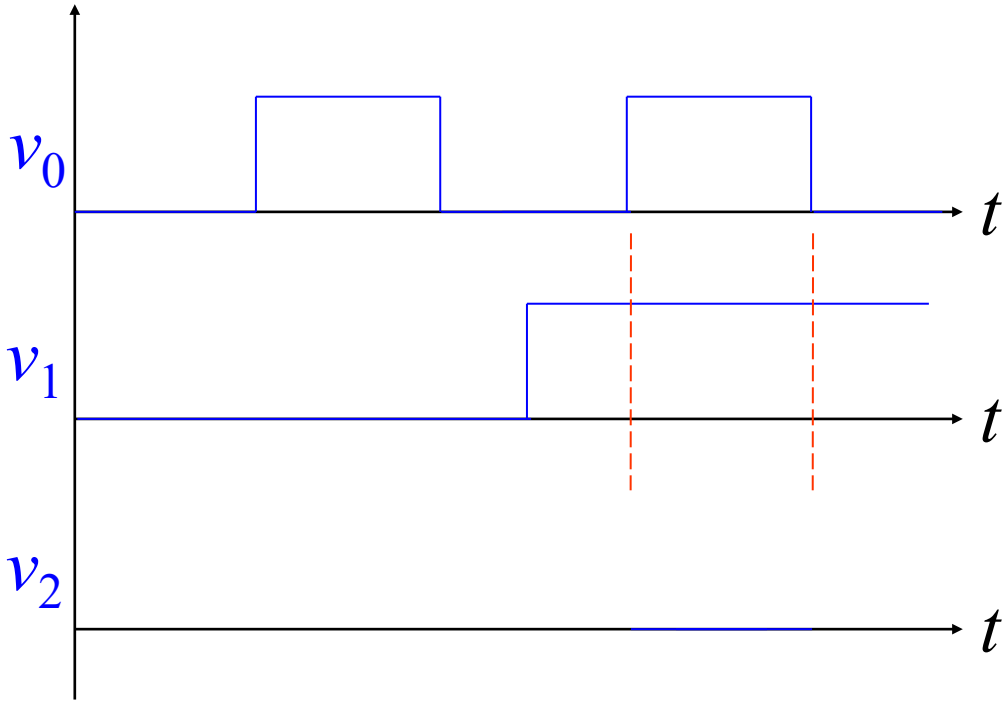


$I_1 = 2.4$ [mA]
$I_2 = 0$ [mA]

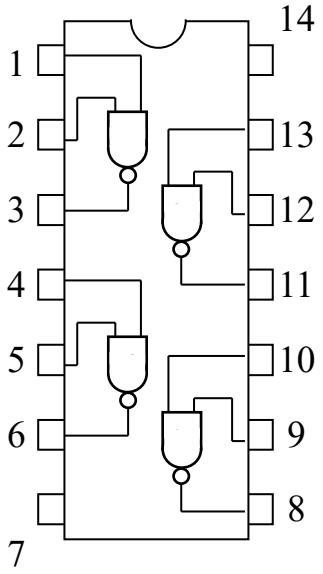
$V_1 = V_2$

NAND回路



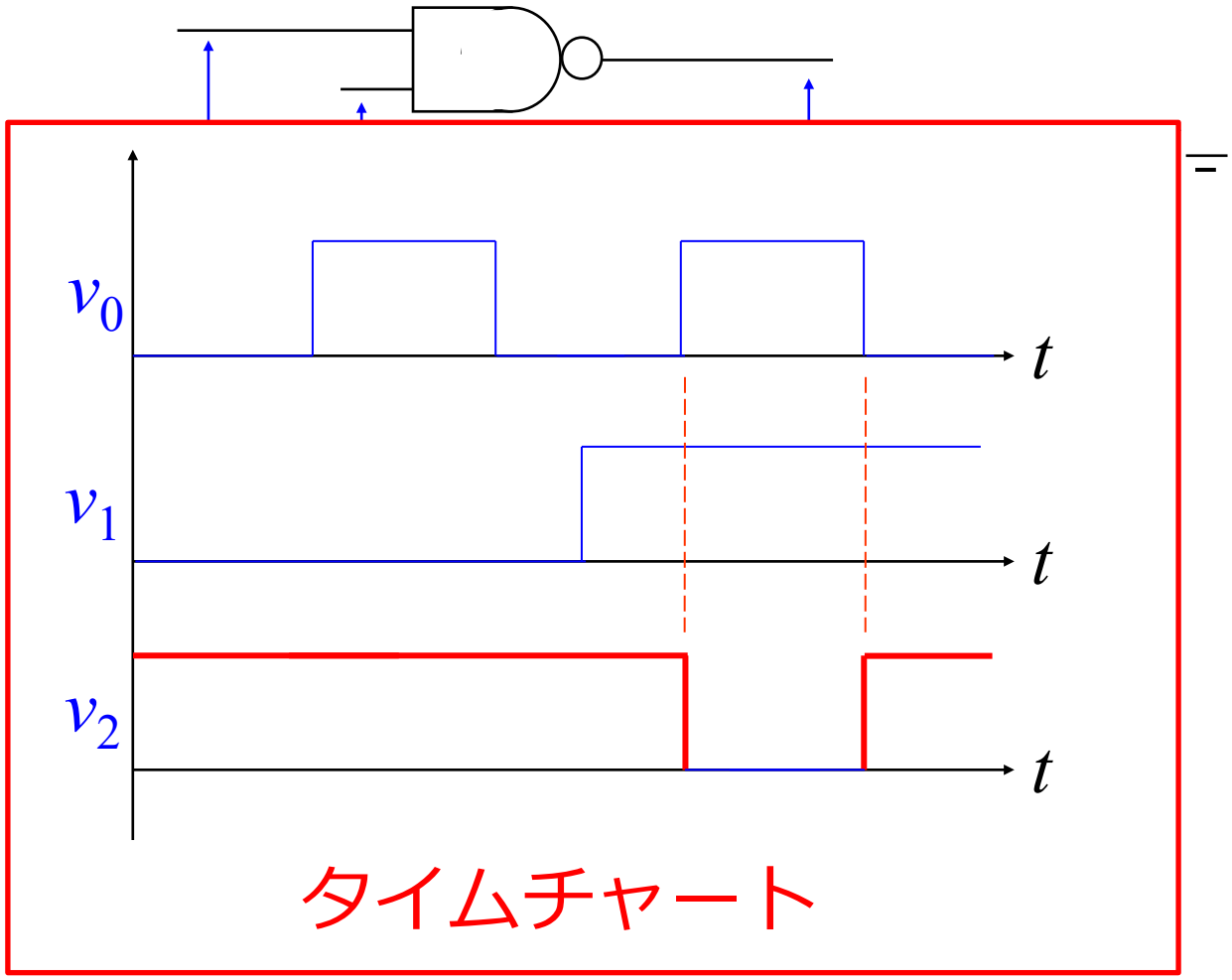


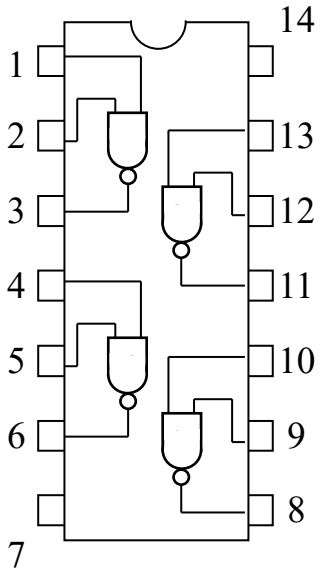
4.5V



TC74HC00AP
NAND回路

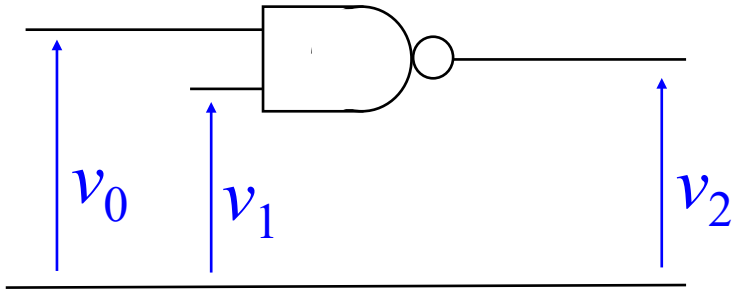
NAND回路

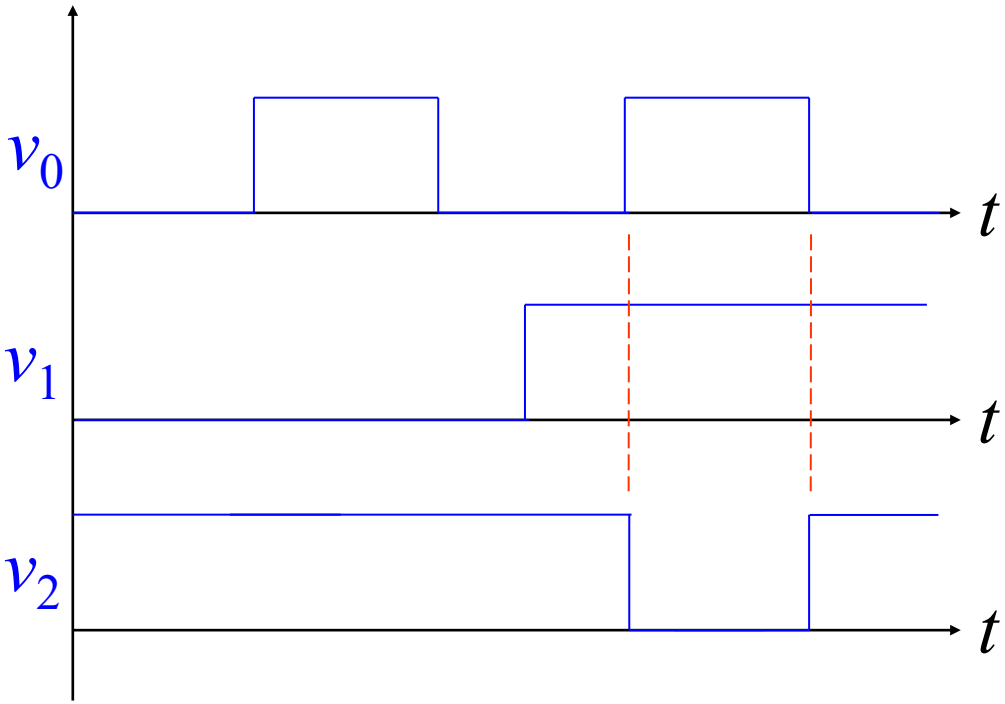




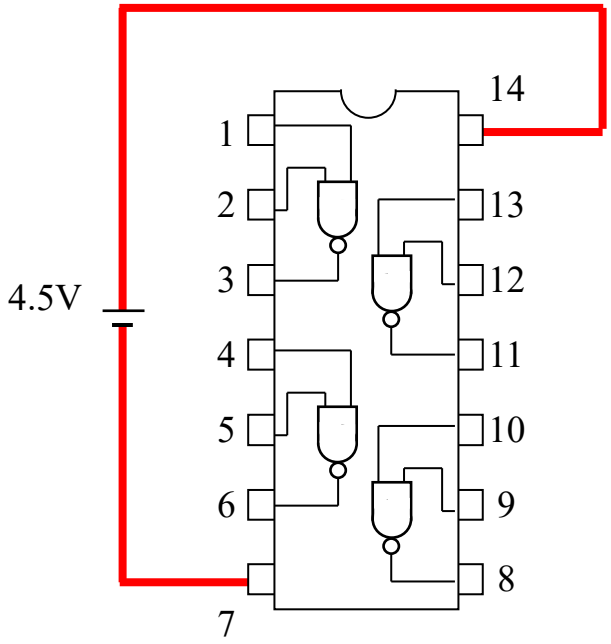
TC74HC00AP
NAND回路

NAND回路



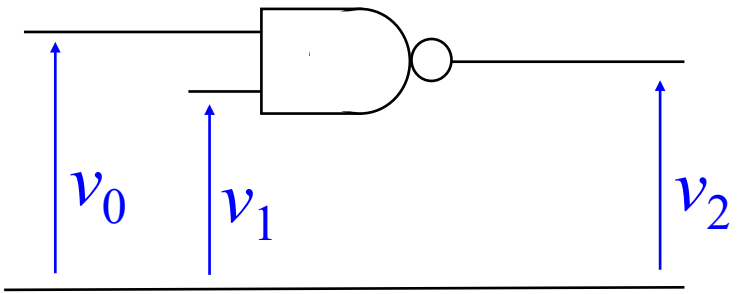


タイムチャート



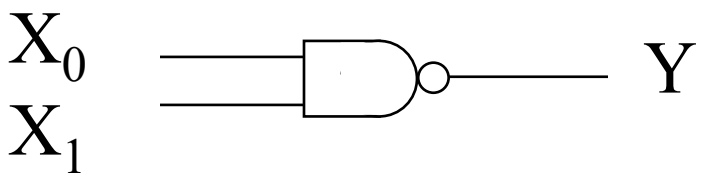
TC74HC00AP
NAND回路

v_1[v]	v_0[v]	v_2[v]

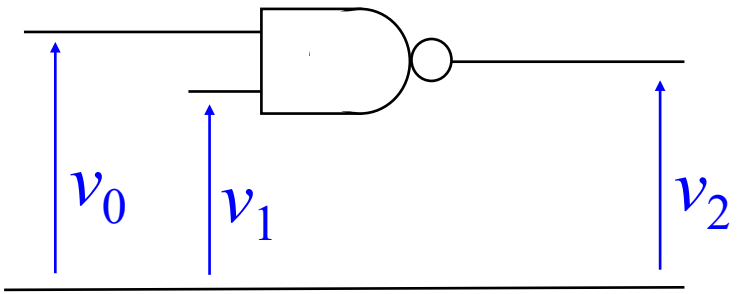


真理値表

X_1	X_0	Y

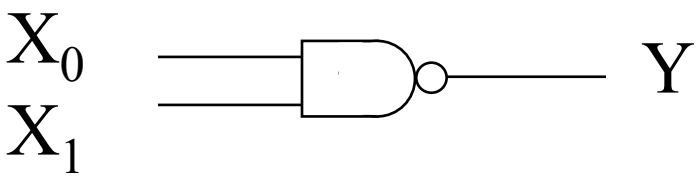


Y ＝



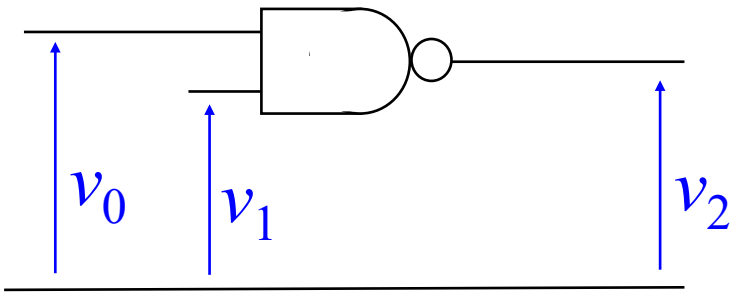
v_1[v]	v_0[v]	v_2[v]
0	0	4.5
0	4.5	4.5
4.5	0	4.5
4.5	4.5	0

真理値表

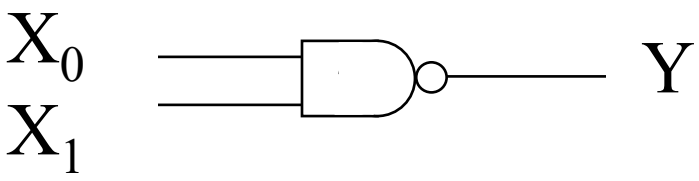


X_1	X_0	Y

Y ＝



v_1[v]	v_0[v]	v_2[v]
0	0	4.5
0	4.5	4.5
4.5	0	4.5

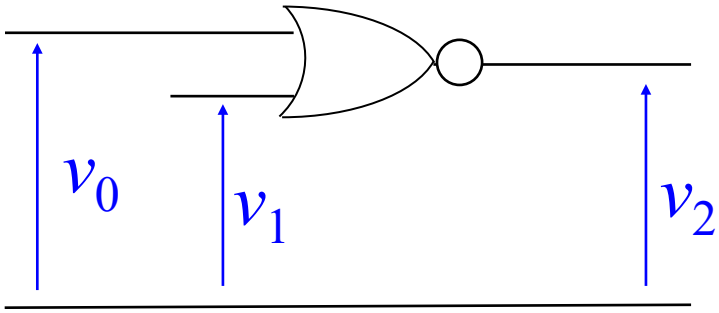


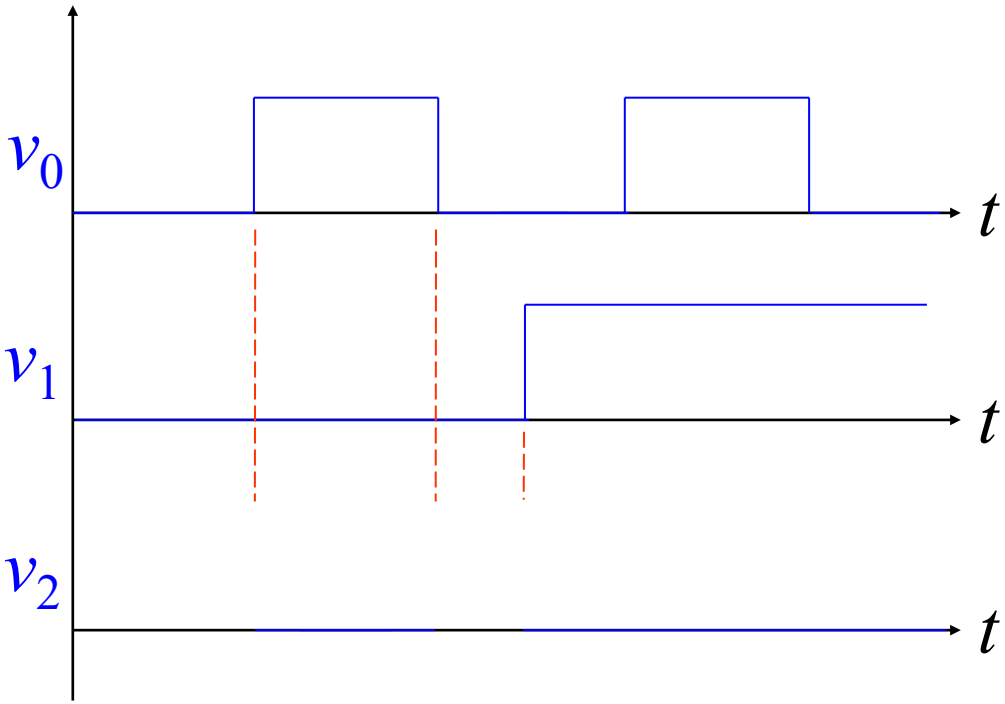
$$Y = \overline{X_1 X_0}$$

真理値表

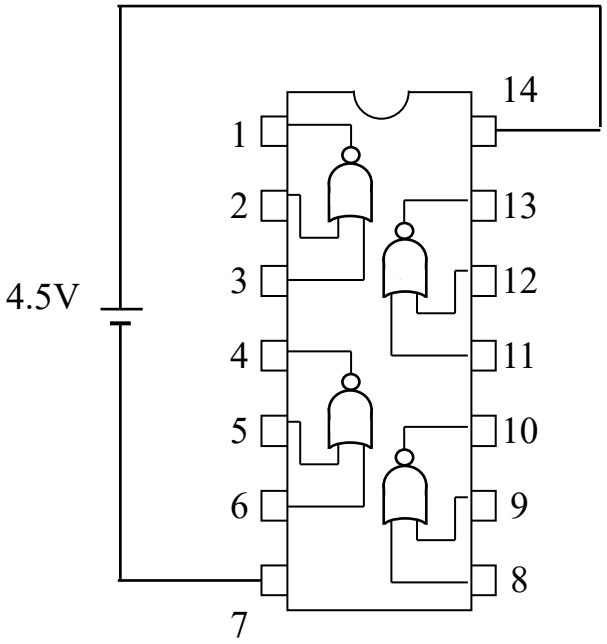
X_1	X_0	Y
0	0	1
0	1	1
1	0	1
1	1	0

NOR回路





タイムチャート



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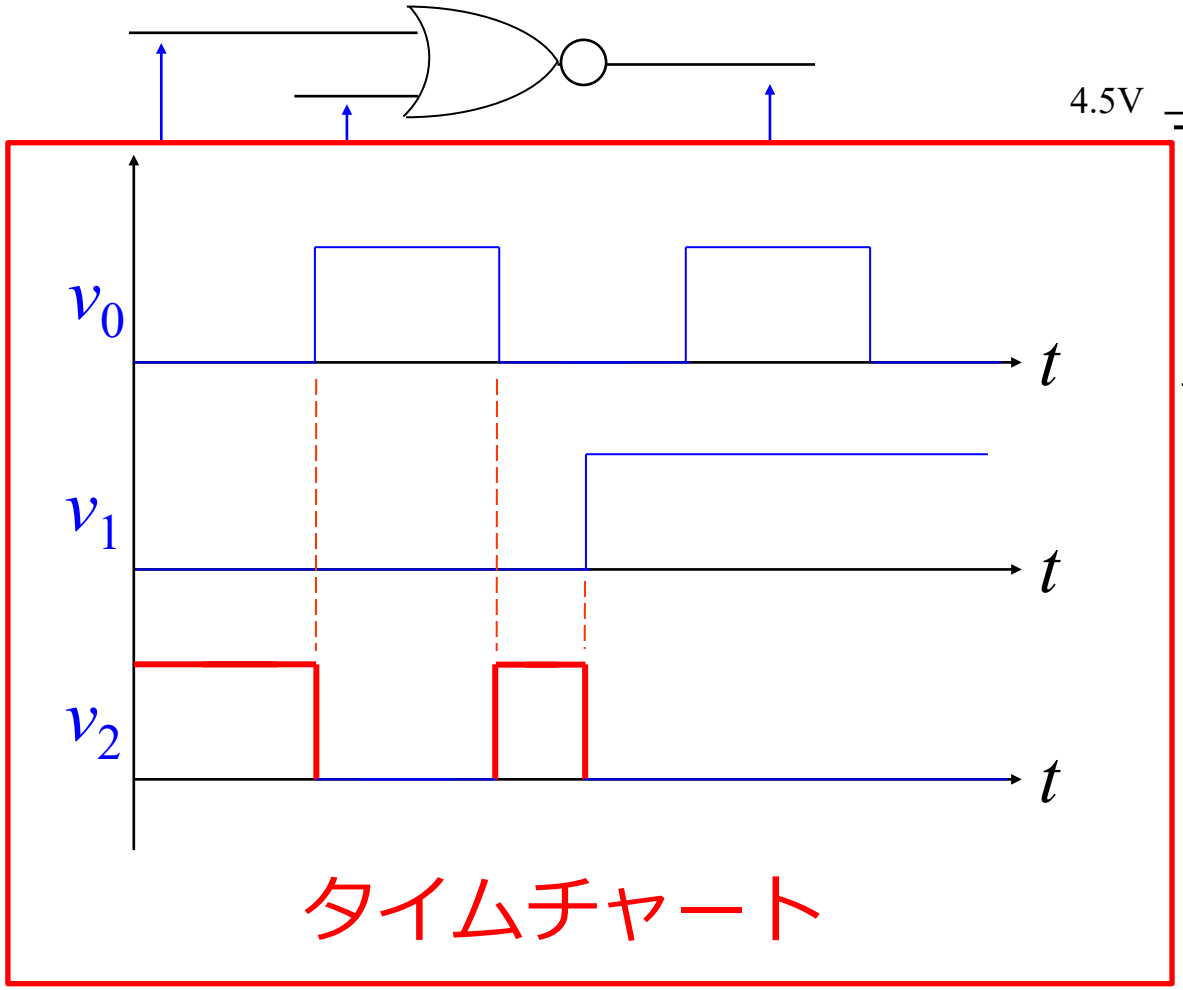
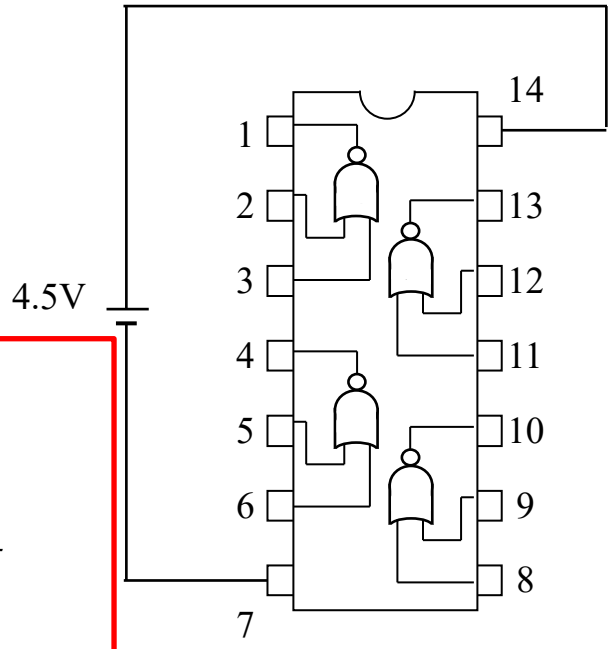
NOR回路

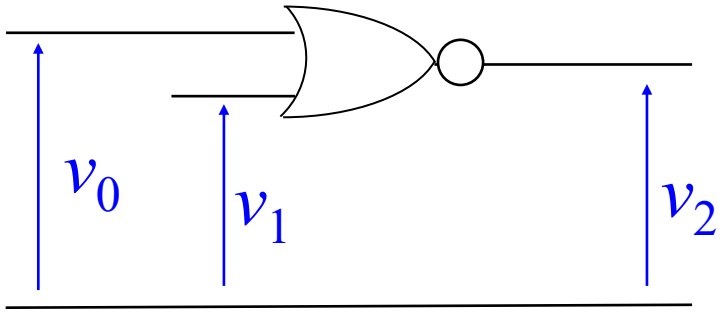
NOR回路



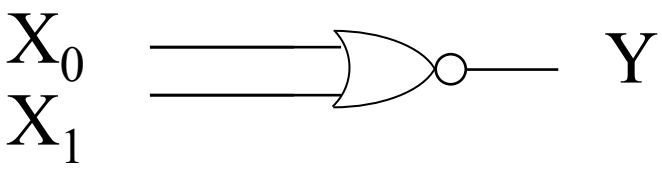


TC74HC02AP
NOR回路

v_1[v]	v_0[v]	v_2[v]

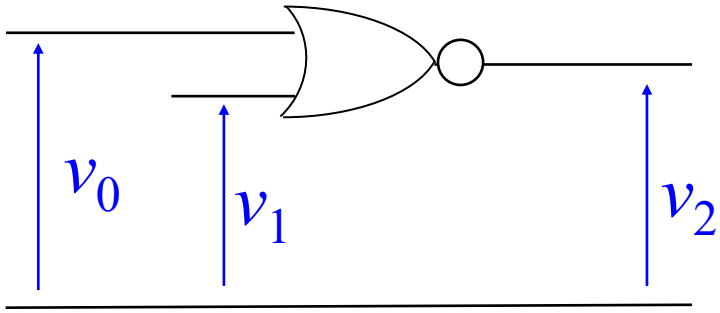


真理値表



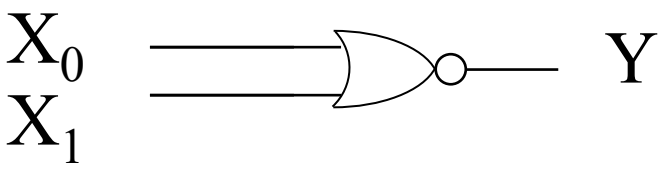
X_1	X_0	Y

Y ＝



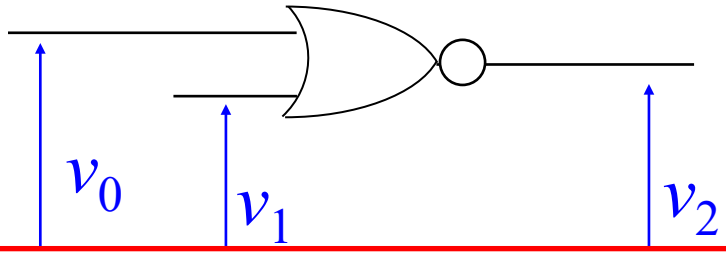
v_1[v]	v_0[v]	v_2[v]
0	0	4.5
0	4.5	0
4.5	0	0
4.5	4.5	0

真理値表

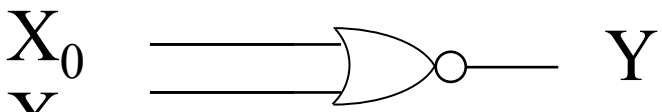


X_1	X_0	Y

Y ＝



v_1[v]	v_0[v]	v_2[v]
0	0	4.5
0	4.5	0
4.5	0	0

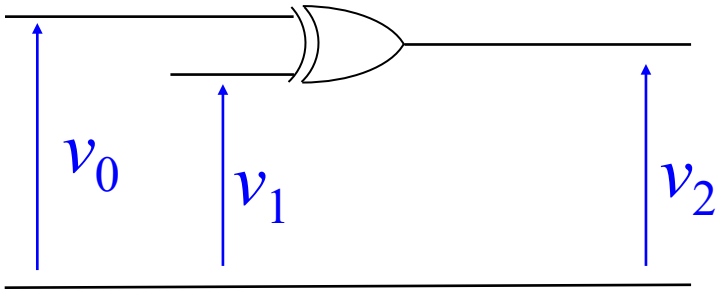


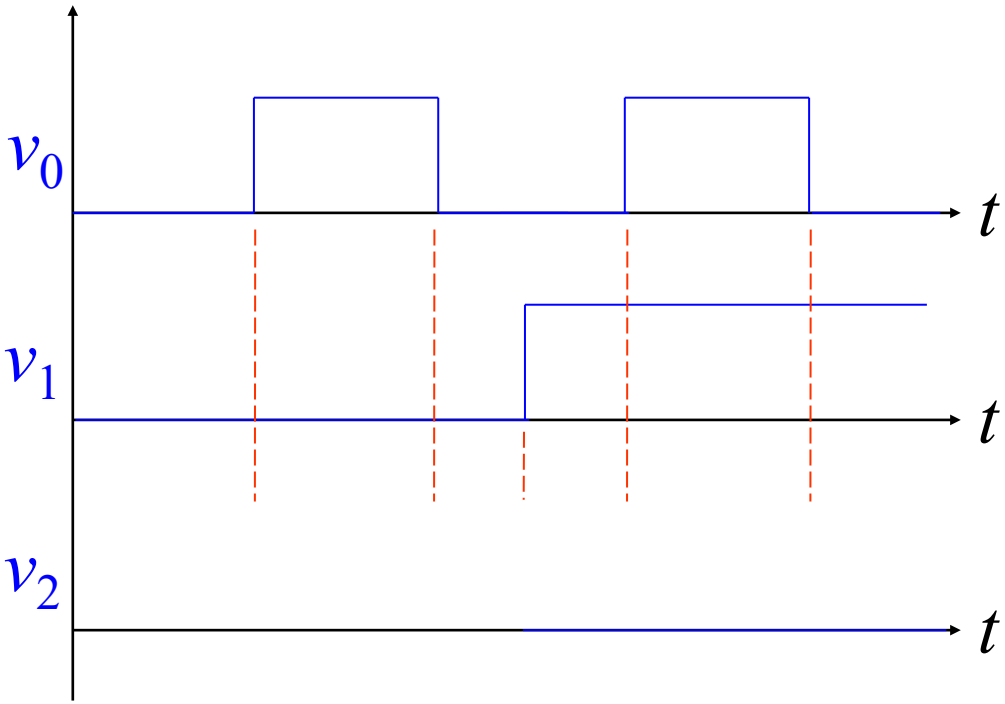
$$Y = \overline{X_1 + X_0}$$

真理値表

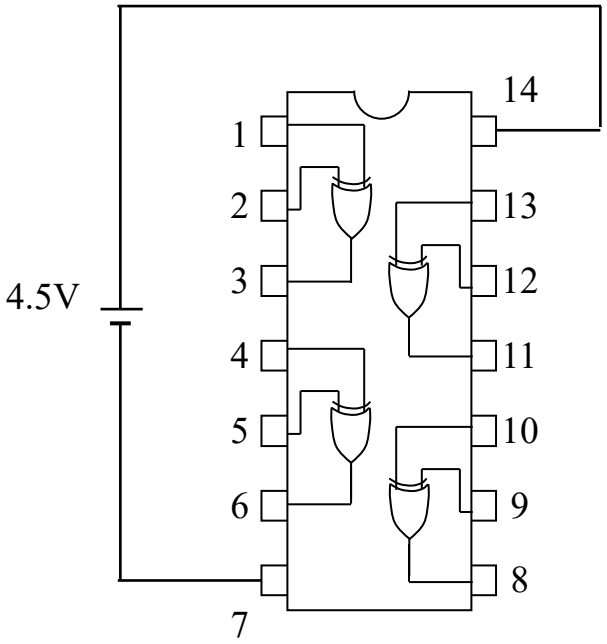
X_1	X_0	Y
0	0	1
0	1	0
1	0	0
1	1	0

XOR回路





タイムチャート



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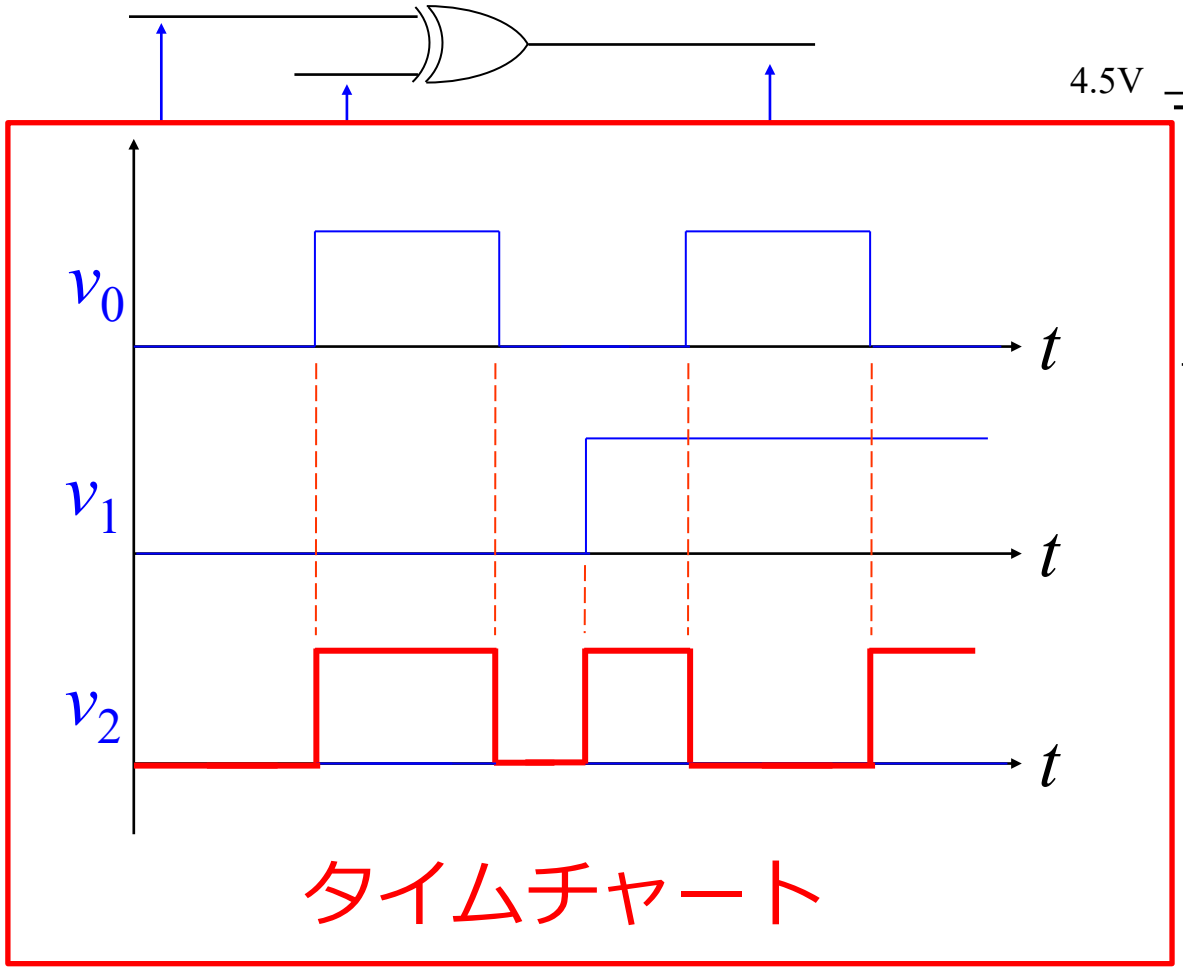
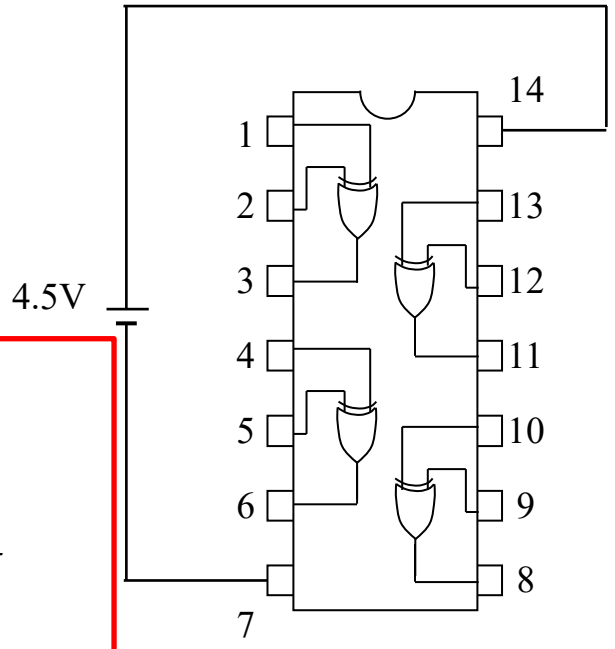
XOR回路

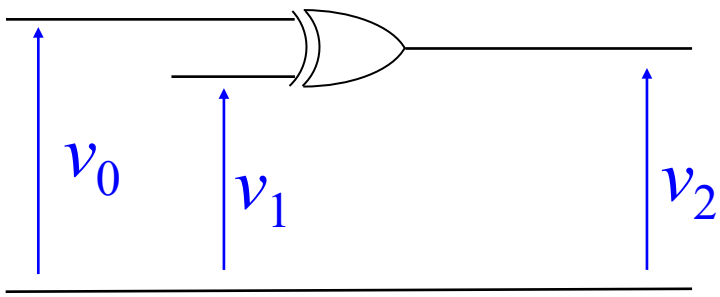
XOR回路



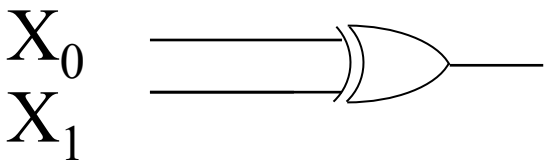


TC74HC86AP
XOR回路

v_1[v]	v_0[v]	v_2[v]

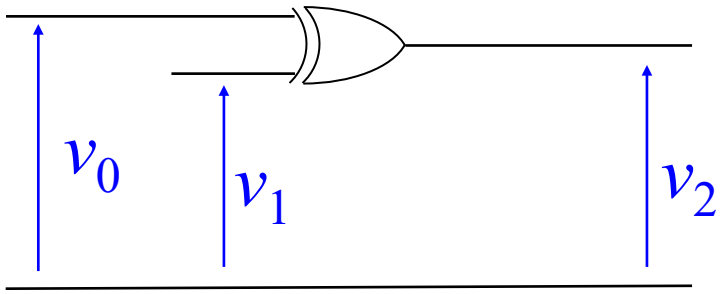


真理値表



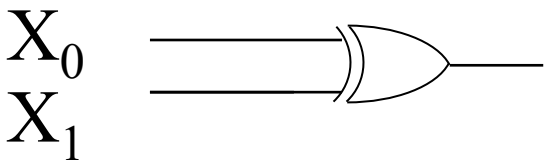
X_1	X_0	Y

Y ＝



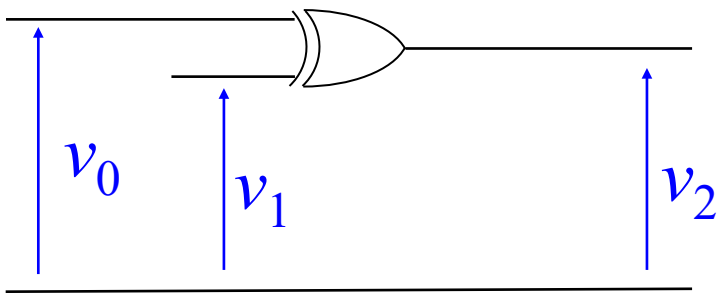
v_1[v]	v_0[v]	v_2[v]
0	0	0
0	4.5	4.5
4.5	0	4.5
4.5	4.5	0

真理値表

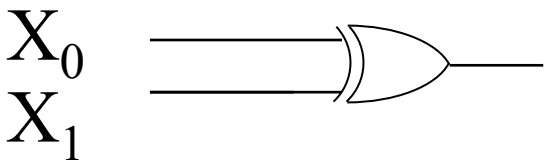


X_1	X_0	Y

Y ＝



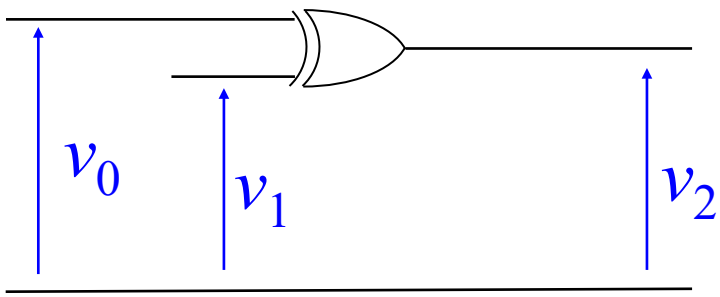
v_1[v]	v_0[v]	v_2[v]
0	0	0
0	4.5	4.5



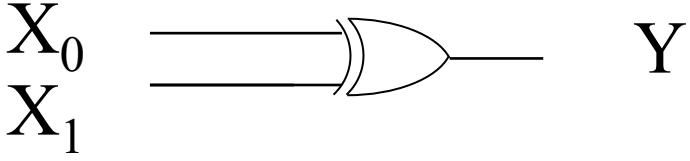
Y ＝

真理値表

X_1	X_0	Y
0	0	0
0	1	1
1	0	1
1	1	0



v_1[v]	v_0[v]	v_2[v]
0	0	0
0	4.5	4.5
4.5	0	4.5
4.5	4.5	0



真理値表

$$Y = \overline{X}_1 X_0 + X_1 \overline{X}_0$$

$$= X_1 \oplus X_0$$

X_1	X_0	Y
0	0	0
0	1	1
1	0	1
1	1	0

$$Y = \overline{X_1}\, X_0 + X_1\, \overline{X_0}$$

$$= X_1 \oplus X_0$$

XORのもう一つの論理式

$$Y = \overline{X}_1 X_0 + X_1 \overline{X}_0$$

$$= X_1 \oplus X_0$$

XORのもう一つの論理式

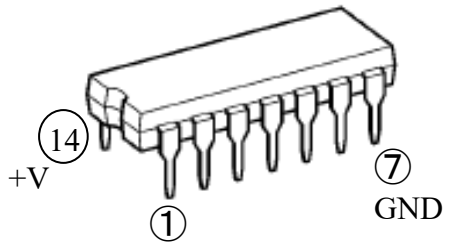
$$Y = \overline{\overline{X}_1 X_0 + X_1 \overline{X}_0}$$

$$= \overline{\overline{X}_1 X_0} \cdot \overline{X_1 \overline{X}_0}$$

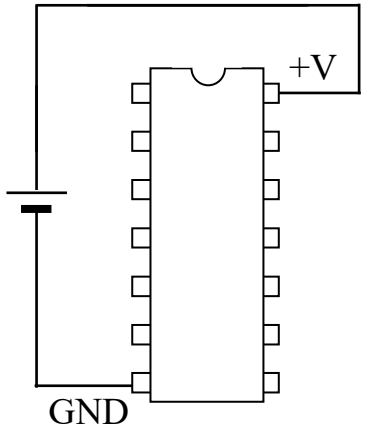
$$= \left(X_1 + \overline{X}_0\right)\left(\overline{X}_1 + X_0\right)$$

$$= X_1 \overline{X}_1 + X_1 X_0 + \overline{X}_1 \overline{X}_0 + \overline{X}_0 X_0$$

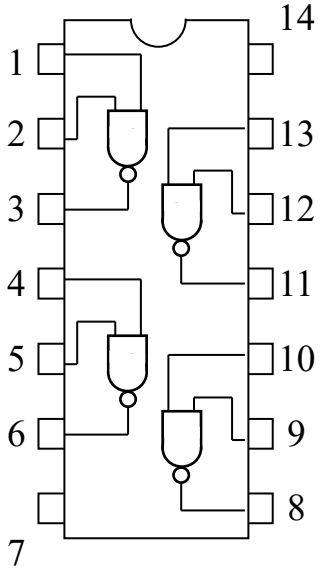
$$= X_1 X_0 + \overline{X}_1 \overline{X}_0$$



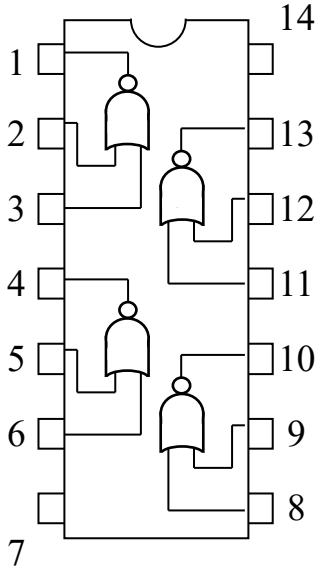
ディジタルICの立体図



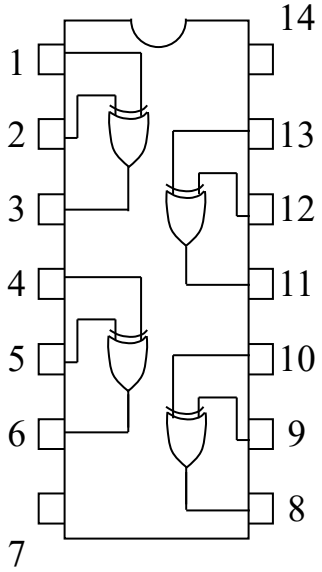
ディジタルICの電源配線



TC74HC00AP
NAND回路



TC74HC02AP
NOR回路



TC74HC86AP
XOR回路

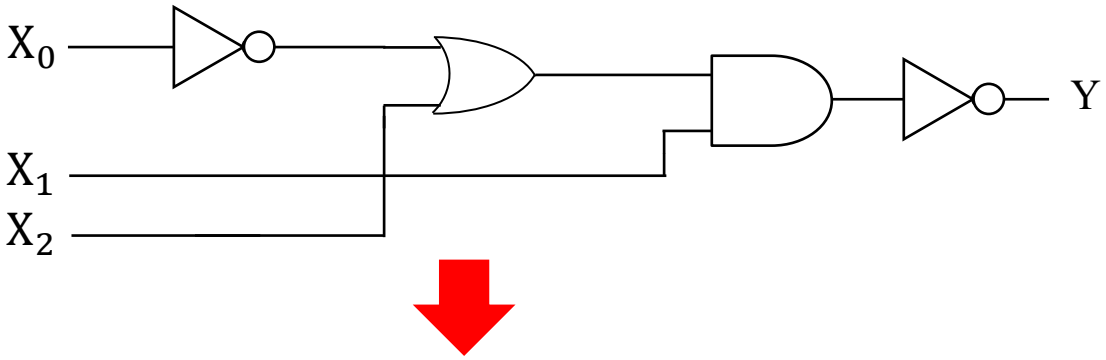
STEP3の レポート課題　NANDによる簡単化

(1)

X_2	X_1	X_0	Y
0	0	0	1
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	0
1	1	1	0

$$\overline{Y} = \overline{X_2}\,X_1\,\overline{X_0} + X_2\,X_1\overline{X_0} + X_2\,X_1X_0$$
$$= X_1\overline{X_0} + X_2\,X_1$$
$$= \left(X_2 + \overline{X_0}\right)X_1$$

$$Y = \overline{\left(X_2 + \overline{X_0}\right)X_1}$$
$$= \overline{\overline{X_2}\,X_0\,X_1}$$

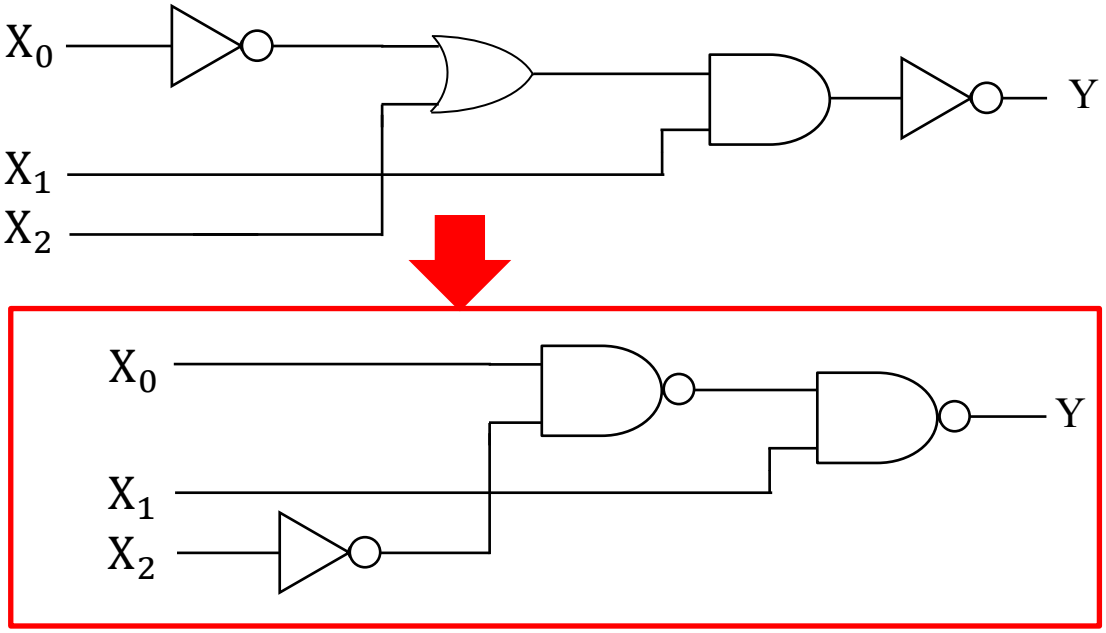


STEP3の レポート課題　NANDによる簡単化

(1)

X_2	X_1	X_0	Y
0	0	0	1
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	0
1	1	1	0

$$\overline{Y} = \overline{X_2}\,X_1\,\overline{X_0} + X_2\,X_1\overline{X_0} + X_2\,X_1X_0$$
$$= X_1\overline{X_0} + X_2\,X_1$$
$$= \left(X_2 + \overline{X_0}\right)X_1$$
$$Y = \overline{\left(X_2 + \overline{X_0}\right)X_1}$$
$$= \overline{\overline{X_2}\,X_0\,X_1}$$

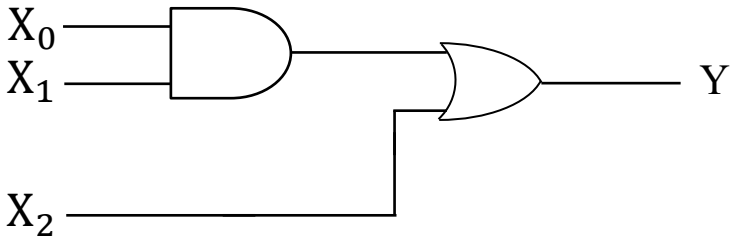


STEP3のレポート課題　NAND, NOTによる変形

(2)

X_2	X_1	X_0	Y
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	1

$$\overline{Y} = \overline{X_2}\,\overline{X_1}\,\overline{X_0} + \overline{X_2}\,\overline{X_1}\,X_0 + \overline{X_2}\,X_1\overline{X_0}$$
$$= \overline{X_2}\,\overline{X_1} + \overline{X_2}\,\overline{X_0}$$
$$= \overline{X_2}\left(\overline{X_1} + \overline{X_0}\right)$$
$$Y = \overline{\overline{X_2}\left(\overline{X_1} + \overline{X_0}\right)}$$
$$= \overline{\overline{X_2}\left(\overline{X_1} + \overline{X_0}\right)}$$
$$= \overline{\overline{X_2}\,\overline{X_1}\,\overline{X_0}}$$

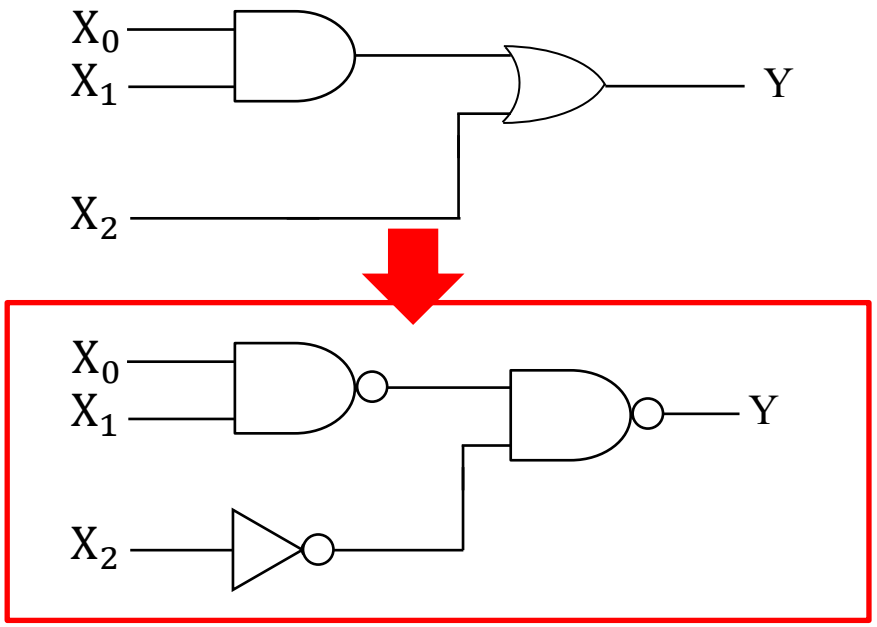


STEP3のレポート課題　NAND, NOTによる変形

(2)

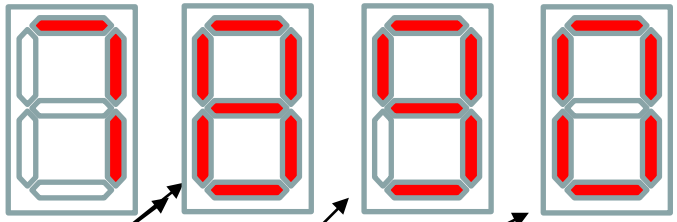
X_2	X_1	X_0	Y
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	1

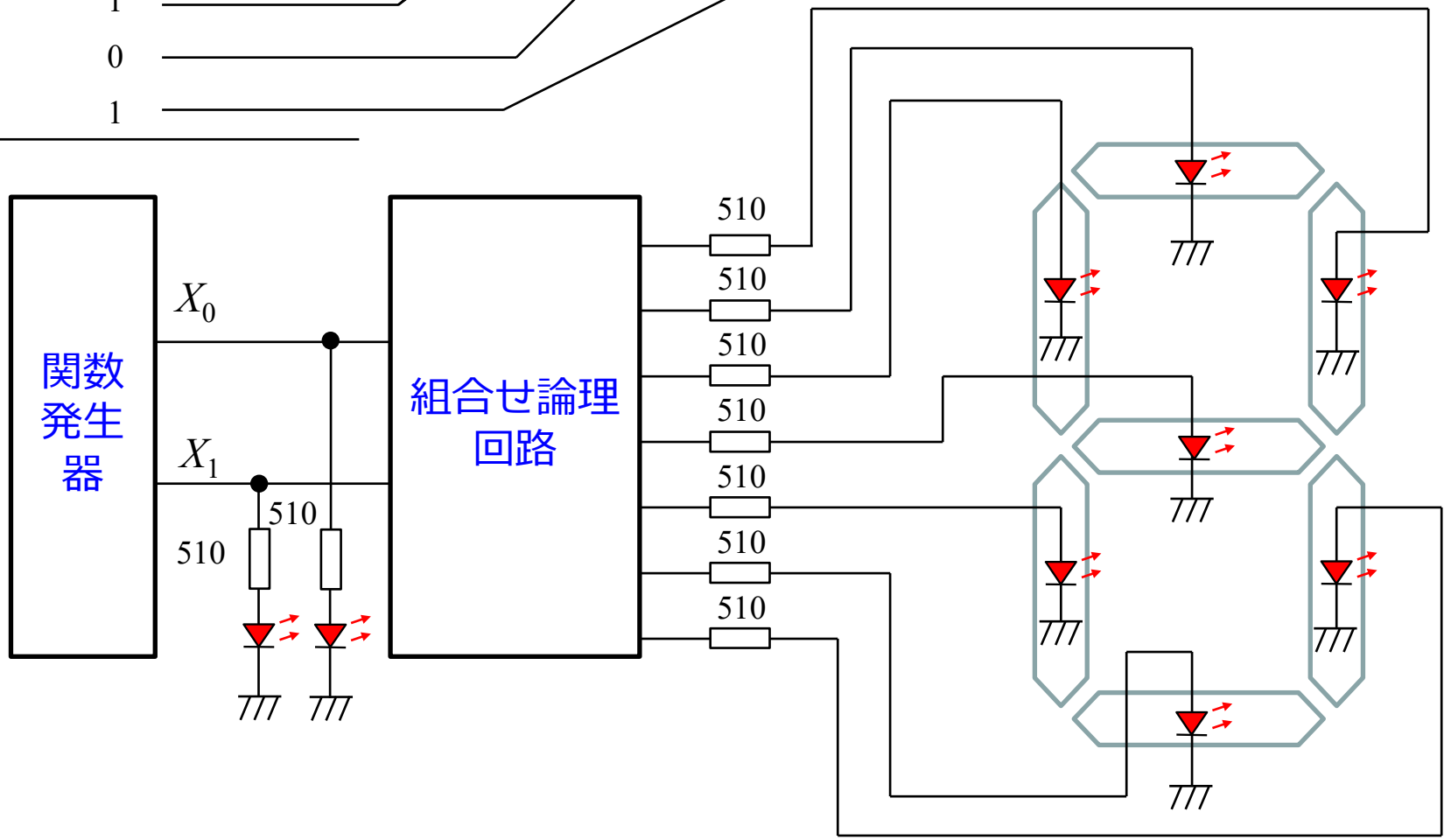
$$\overline{Y} = \overline{X_2}\,\overline{X_1}\,\overline{X_0} + \overline{X_2}\,\overline{X_1}\,X_0 + \overline{X_2}\,X_1\overline{X_0}$$
$$= \overline{X_2}\,\overline{X_1} + \overline{X_2}\,\overline{X_0}$$
$$= \overline{X_2}\left(\overline{X_1} + \overline{X_0}\right)$$
$$Y = \overline{\overline{X_2}\left(\overline{X_1} + \overline{X_0}\right)}$$
$$= \overline{\overline{X_2}\left(\overline{X_1} + \overline{X_0}\right)}$$
$$= \overline{\overline{X_2}\,\overline{X_1}\,\overline{X_0}}$$



STEP5　製作演習　以下の7セグメント表示器の論理回路をNAND, NOR, NOT, XORの中から適当なものを用いて設計せよ．論理回路は3つで済む．導出の過程と，設計した論理回路図も併せて提出せよ．

X_1 (v_1)	X_0 (v_0)
0	0
0	1
1	0
1	1





STEP5　レポート課題

次の真理値表を論理回路で実現せよ。できるだけ論理回路の数を少なくせよ．AND, OR, NOT, NAND, NOR, ＸＯＲのいずれを用いても良い．導出の過程も示せ．

（ボーナス課題）この論理回路を製作してTAのチェックを受ければ，小問1問につき＋1点とする．（締め切り：次回の講義開始時点）

(1)

X_2	X_1	X_0	Y
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	0

(2)

X_3	X_2	X_1	X_0	Y
0	0	0	0	1
0	0	0	1	1
0	0	1	0	1
0	0	1	1	1
0	1	0	0	1
0	1	0	1	1
0	1	1	0	1
0	1	1	1	1
1	0	0	0	1
1	0	0	1	1
1	0	1	0	0
1	0	1	1	0
1	1	0	0	1
1	1	0	1	1
1	1	1	0	0
1	1	1	1	0